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CALIFORNIA ENERGY FLOW IN 1991

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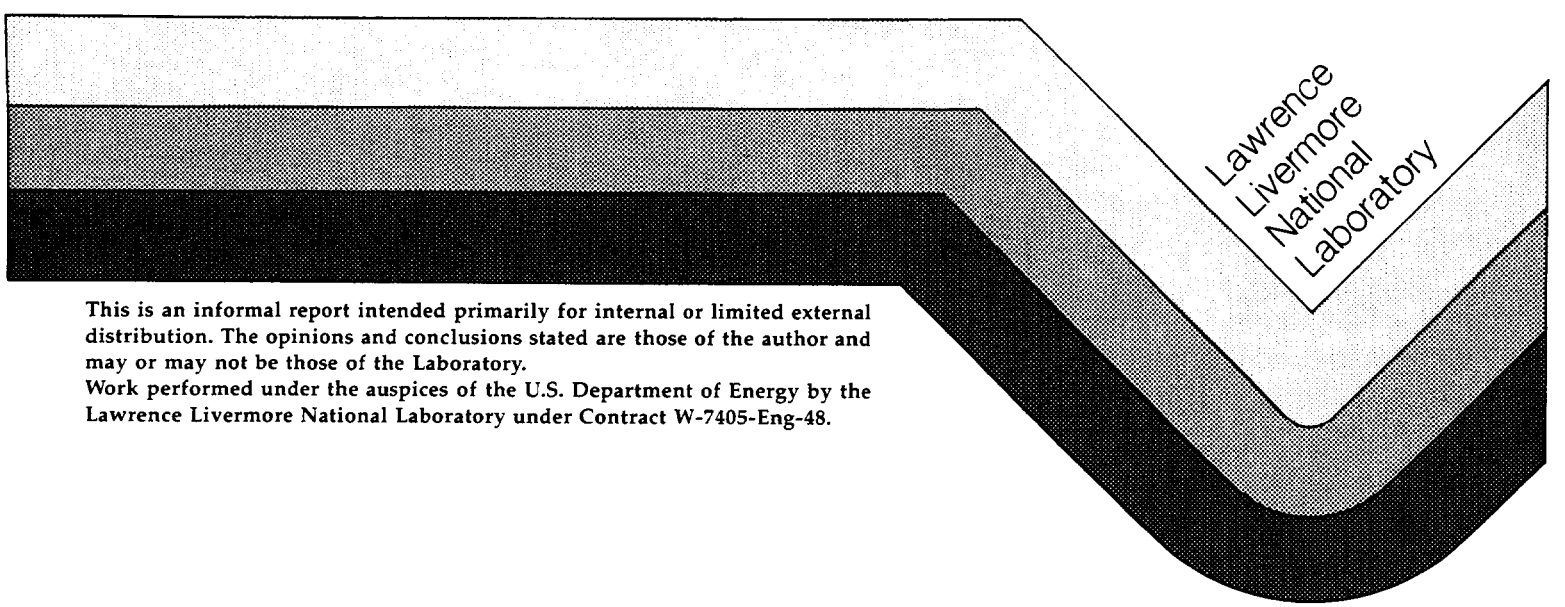

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ABSTRACT

Energy consumption in California fell 1.4% in 1991 for the first time in five years. The State's economy was especially hard hit by a continuing national recession which resulted in a 7.7% unemployment rate compared to 6.7% for the nation as a whole. The construction industry for the second year experienced a dramatic downturn as judged by the value and number of authorized new building permits. Although energy use in the industrial sector showed a modest increase, consumption in other end-use categories declined. The decrease in overall energy used in transportation can be traced to a substantial fall in the sales of both highway diesel fuels and vessel bunkering fuels at California ports, the latter reflecting a mid-year increase in taxes. Gasoline sales by contrast increased as did the number of miles traveled and the number of automobile registrations in the State. The steady growth in population has more than compensated for improved vehicular fuel efficiencies and enlarged use of mass transit systems.

Production in California's oil and gas fields was at 1990 levels thus arresting what has been a steady decline in output. Due to enlarged steam flooding operations, production at several fields reached record levels. Noteworthy among them was the Midway-Sunset field which became the largest producer in the lower 48 states. Also countering the long term decline in many of California fields was new production from the Port Arguello offshore field. Its oil reached refineries for the first time after its operators reached an interim agreement with Santa Barbara County on transport of the oil to shore. California natural gas production, despite a modest 1991 increase, does not promise to fill the expected increased use within the State. In 1991 State production comprised eighteen percent of total natural gas demand.

Overall, petroleum comprised more than half of the State's energy supply principally for transportation. Natural gas use showed a small increase as it continued to displace oil in steam production in enhanced oil recovery operations and remained the favorite fuel of a growing number of cogenerators. Oil products play virtually no role in electrical production. The largest single source of electricity to the State is imports from the Pacific Northwest and from coal-fired generating plants in the Southwest. Combined contributions to transmitted electricity from renewable and alternate sources declined as hydropower was constrained by a prolonged drought and as geothermal power from the largest and oldest field at The Geysers fell. Windpower grew slightly; however solar power remained at 1990 levels and made no substantial contribution to total power generation.

INTRODUCTION

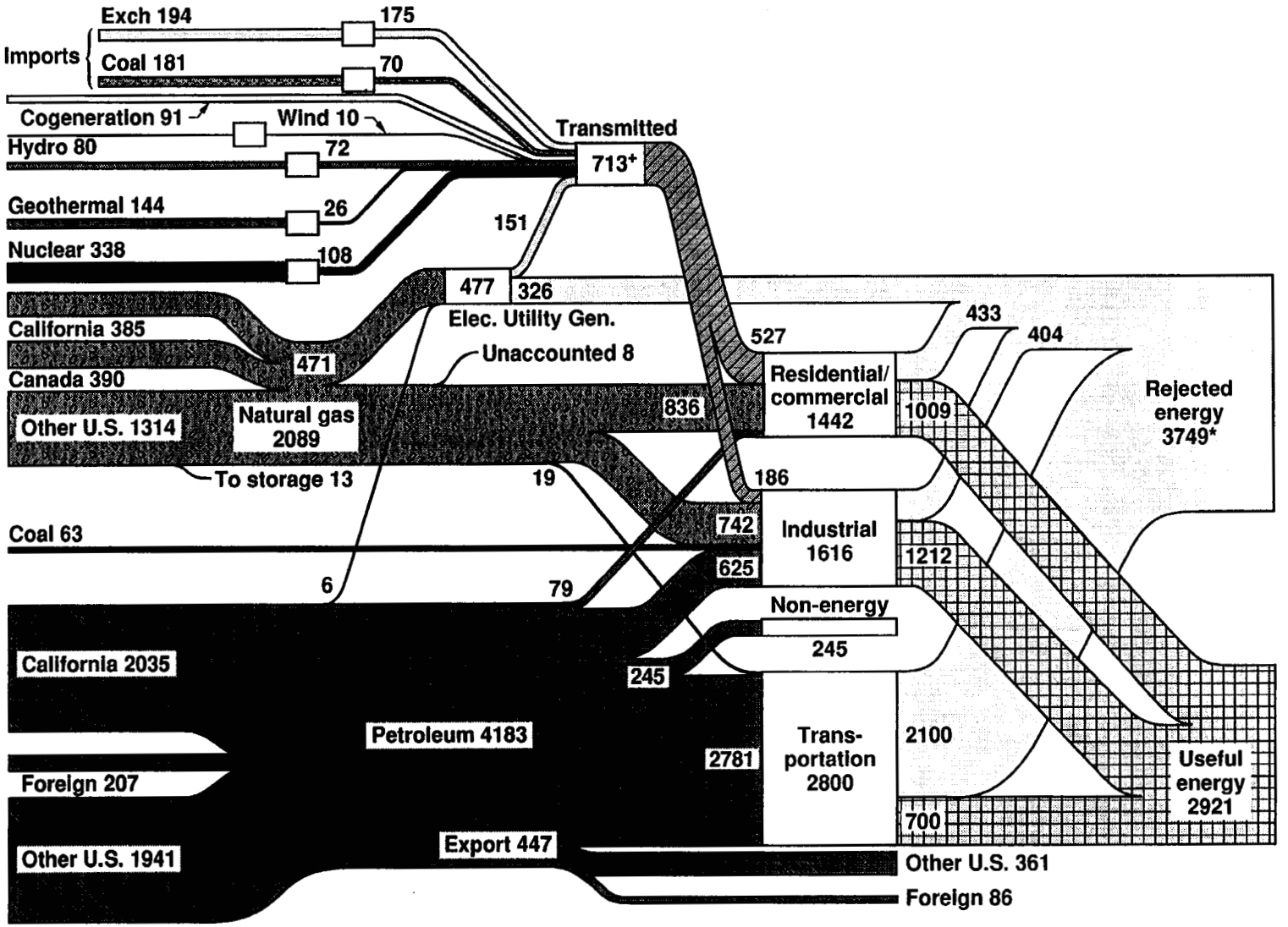
For the past sixteen years energy flow diagrams for the State of California have been prepared from available data by members of the Lawrence Livermore National Laboratory.[1] They have proven to be useful tools in graphically expressing energy supply and use in the State as well as illustrating the difference between particular years and between the State and the US as a whole.

As far as is possible, similar data sources have been used to prepare the diagrams from year to year and identical assumptions[1a-1c] concerning conversion efficiencies have been made in order to minimize inconsistencies in the data and analyses. Sources of data used in this report are given in Appendix B and C; unavoidably the sources used over the 1976-1992 period have varied as some data bases are no longer available. In addition, we continue to see differences in specific data reported by different agencies for a given year. In particular, reported data on supply and usage in industrial/commercial/residential end-use categories have shown variability amongst the data gathering agencies, which bars detailed comparisons from year to year. Nonetheless, taken overall, valid generalizations can be made concerning gross trends and changes.

CALIFORNIA ENERGY FLOW DIAGRAMS

California energy flow diagrams for 1991 and 1990 are shown in Figures 1 and 2 respectively. For comparison the US energy flow for 1991[2] is shown in Figure 3. Energy sources are shown on the left and energy consumption is shown on the right. The energy balance between the two is given in Appendix A. Also shown on the right are estimates of conversion efficiencies in the end-use sector, which result in a division between useful and rejected energy. The latter consists primarily of heat losses but also includes other sorts of losses such as line losses during electrical transmission. Inputs to total transmitted electricity such as nuclear, geothermal power, etc., are associated with estimated efficiencies of the conversion process to electricity. They vary from 90 percent in the case of hydroelectric power to 18% for geothermal energy. Assumptions concerning the conversion efficiencies are given in Appendix D, and their rationale can be found in Ref. 1b and 1c. The box separating the energy source from the final electrical output represents the conversion process. In all cases the quantities associated with the energy source are calculated based on the assumed conversion efficiencies. While it is desirable to minimize the number of assumptions in preparing an energy flow diagram, it is also desirable to express as closely as possible the energy content of the sources used during the year. In this way changes and improvements in overall fuel conversions that occur over the course of time by virtue of fuel switching and use of renewable sources such as windpower or solar energy have an expression in the total energy consumption in the State.

CALIFORNIA ENERGY FLOW -1991
TOTAL CONSUMPTION 6800 × 10^{12} Btu



+ Includes 10 units from miscellaneous sources

* Includes rejected energy for hydro, coal, geothermal, and nuclear conversions

Figure 1

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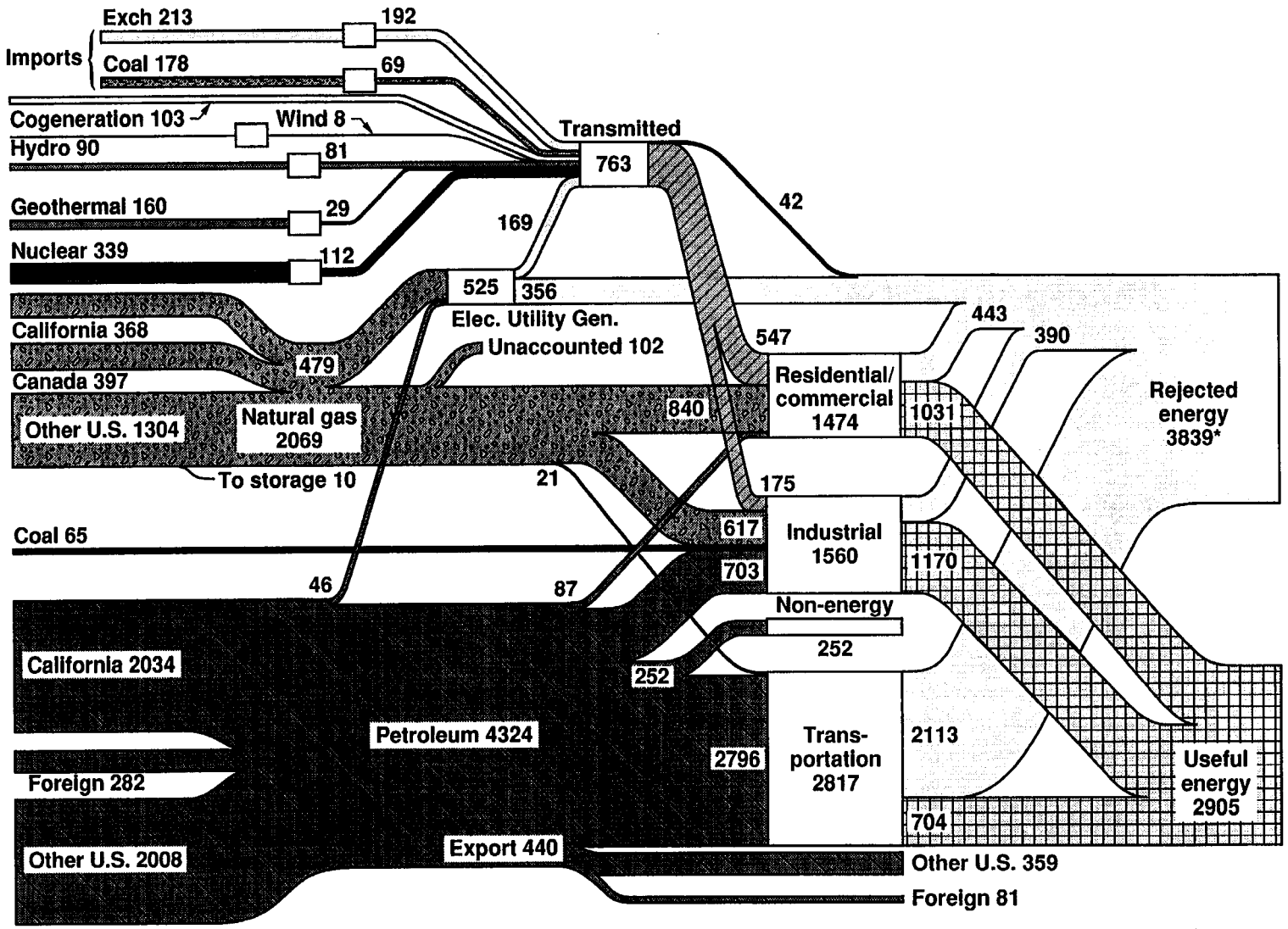
CALIFORNIA ENERGY FLOW -1990
TOTAL CONSUMPTION 6900 × 10^{12} Btu



* Includes rejected energy for hydro, coal, geothermal, and nuclear conversions

Figure 2

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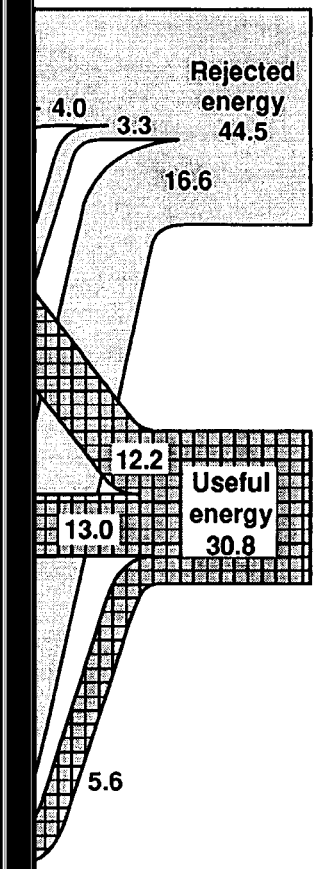

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Power from cogenerators and self-generators shown in the figures as inputs to total transmitted electricity appear without a box (representing the conversion process) that ordinarily would appear between the energy content of the fuel and the final product. In this instance, conversion losses are included in "rejected energy" from the industrial sector.

CALIFORNIA'S ENERGY FLOW IN 1991 COMPARED TO 1990

The economy

In 1991 California was in the midst of what appeared to be the most severe recession since the 1930's. As judged by standard economic indicators (Table 1), the effects have been more profound than in the nation as a whole. At the end of the year unemployment stood at 1.1 million or 7.7% compared the 6.7% for the US.[3]

Table 1. Selected economic data for California - 1991[3]

Indicator	Percent change from 1990
Unemployment	+37.9
Civilian employment	-1.1
Housing units authorized	-33.9
New auto registrations	-8.8
Total taxable sales	-5.5
Corporate profits before taxes	+5.1
Personal income	+1.8
Consumer price index	+4.2

The construction industry was especially hard hit by the sluggish economy (Table 2) as evidenced by the decrease for the third year in the number of authorizations for construction of new multiple residential, commercial and industrial units.

Table 2. Construction authorized by permit - 1991[4]

(Value in Millions of Dollars)

Year	Residential	Nonresidential	
		Commercial	Other*
1988	26,361	6,569	7,592
1989	27,790	6,159	7,507
1990	20,686	5,270	7,466
1991	15,056	3,374	6,247

*Other consists of all other categories including additions and alterations of $100,000 or more.

Energy Consumption

For the second year energy consumption fell reflecting the continuing recession and to some extent conservation measures. Industrial consumption increased in 1991 (Table 3), in part reflecting a 8.8% increase in prime defense contracts for the fiscal year ending September 1991.[5] Although Federal budget proposals and likely Congressional action point to a downward trend in Department of Defense and Department of Energy contracting, in FY1991 California received an additional $1.95 billion of the $3.7 billion increase in total Department of Defense contracts. Fuels use by the industrial sector (compare Figure 1 and 2) also saw change as natural gas continued to displace oil - in enhanced oil recovery operations and in electrical generation and self-generation. Natural gas used at leases (for field compressors, heaters, drilling, dehydrators) and in natural gas processing plants also showed a several fold increase in 1991; the amounts are included in consumption within the industrial sector.

The residential/commercial sector usage fell slightly; the largest decreases were registered in electricity use, which was most likely due to reduced commercial activity, offset to some extent by population increase. Statewide temperatures for the year (Table 4) were slightly cooler than the previous year but warmer than the 25 year average. The 1951-1980 average shown in Table 4 for Los Angeles (1204 heating degree days) is anomalous since it has been exceeded in only three years since 1967. The explanation may lie in the so-called urban effect whereby ambient temperatures are increased as a consequence of activities of a concentrated population.

Table 3. Comparison of Annual Energy Use in California

(in 10^{12} Btu)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Natural Gas	2010	893	1769	1865	2034	1697	2091	1932	2087	2069	2089
Crude Oil (less exports)	3650	3327	3329	3477	3580	3601	3591	3899	4015	3884	3736
Transmitted Electricity	620	642	622	700	673	697	718	744	757	763	713
Residential/Commercial	1370	1225	1268	1176	1325	1224	1325	1350	1403	1474	1442
Industrial	1400	1570	1395	1493	1648	1456	1439	1557	1646	1560	1616
Non-energy	165	158	183	221	185	203	292	235	237	252	245
Transportation	2430	2265	2313	2464	2384	2499	2564	2715	2781	2817	2800
Total Energy Consumption†	6300	6000	5900	6200	6400	6200	6600	6750	6950	6900	6800

† Total is not sum of above figures because of rounding and inclusion of losses associated with conversion to electrical energy.

Table 4. Weather Comparison, 1967 - 1991

(Annual Heating Degree Days**)

	San Francisco Federal Office Building	Los Angeles Civic Center	San Diego Lindbergh Field
1967	2978	1040	1380
1968	2942	850	1052
1969	3066	1032	1145
1970	3006	941	1137
1971	3468	1424	1657
1972	3240	918	1166
1973	3161	1066	1137
1974	3182	1084	1123
1975	3313	1548	1416
1976	2665	1128	793
1977	2888	911	747
1978	2599	1208	736
1979	2545	1160	902
1980	2799	597	590
1981	2819	506	573
1982	3195	975	913
1983	2386	602	623
1984	2648*	704	713
1985	2486*	921	1079
1986	1842*	473	843
1987	2150*	979	1201
1988	2194*	867	1102
1989	2526*	844	1068
1990	2340*	839	1172
1991	2422*	879	1212
Normal 1951-80	2750***	1204	1284

* CA. Mission Dolores - same historical data as for Federal Office Building.
Source: Local Climatological Data for San Francisco, Los Angeles and San Diego, National Oceanic and Atmospheric Admin., National Climatic Data, Asheville, NC.

** A "degree day" is a term that describes the relationship of energy consumption to outdoor temperatures. "Heating or cooling degree days" are deviations of the mean daily temperature from 65° F. For example for a day with a mean temperature of 40°F, the "heating degree days" would be 25 and the "cooling degree days" 0. Annual heating degree days are the sum for the year. Greater number of heating degree days means greater fuel requirements.

*** Revised by W. J. Koss, NOAA, September 7, 1988.

TRANSPORTATION FUELS

Consumption

The substantial drop in the amount of bunkering fuels sold at California ports (Table 5), probably due to taxes imposed mid-year, resulted in a small decline in the total energy consumed by the State's transportation sector in 1991. An increase in gasoline sales for the year more than compensated for the downturn in sales of bunkering fuels. By any measure - miles traveled on the state highway system, number of automobile registrations or registered drivers - use of motorized vehicles continued to increase in 1991, which is as might be expected from steady increases in the State's population.[6] For the second year use of highway diesel fuels fell reflecting the continuing economic recession. Commercial, gasoline-fueled vehicular traffic must have been similarly affected; however any decrease is masked by increases in other end uses.

Table 5. California Transportation End Use
(in 10^{12} Btu)

	1985	1986	1987	1988	1989	1990	1991
Net gasoline*	1445	1543	1576	1612	1630	1664	1712
Net aviation fuel	379	392	390	427	458	475	476
Taxable diesel fuel -public highways	207	218	174	244	265	253	246
Rail diesel	31	31	30	26	30	31	33
Net bunkering fuel	274	267	347	357	348	344	288
Military	33	35	28	29	30	29	26
Natural gas-pipeline fuel	12	15	13	20	20	21	19
Natural gas vehicular	-	-	-	-	-	0.004	0.01
Total**	2384	2499	2565	2715	2781	2817	2800

* As of January 1, 1992 leaded gas was no longer produced at California refineries.

** Some electricity is used for mass transit; however the amount is not monitored on a state-wide basis and hence does not appear in this table or in Figures 1 and 2.
Source: Fuel and Kerosene Sales, DOE/EIA, 1991; Quarterly Oil Report, Fourth Quarter 91 (Net gasoline and aviation fuel), California Energy Commission, Sacramento, CA; Natural Gas Annual-1991, DOE/EIA-0131(91), Table 48, Department of Energy, Washington, DC (October 1992).

Gasohol sales showed a 27% increase in both 1990 and 1991. Almost 600 million gallons of taxable gasohol were sold in California in 1991 compared to 12.5 billion gallons of highway gasoline and 1.8 billion gallons of taxable diesel fuel - thus four percent of the total on a volumetric basis.[6] As some of this was added to gasoline as an octane booster, the quantity used as a "neat" fuel is not available.

On average across the State, intercity bus travel declined, and use of light rail transport increased. The largest of the rail systems (Bay Area Rapid Transit) in California carried 72 million passengers in 1991, an increase of 1.6% over 1990. Some of the largest percent increases in ridership were recorded by Santa Clara County Transit, (88%) which carried 5.4 million riders and Southern California Rapid Transit District (~48%) which commenced operation in 1990 and counted 9.8 million passengers in 1991.[6]

Automobile emission standards

Near the end of the year the California Air Resources Board (CARB) approved new fuel regulations changing gasoline content, vapor pressure and distillation temperatures at refineries to reduce smog-forming emissions of vehicles. The gasoline reformulation regulations are to go into effect in 1996 and are expected to reduce pollutants by one-third. Adoption of the rules will require refitting all major refineries at a cost of 12 to 17 cents per gallon, which is expected to be passed on to consumers. Although opposed by most oil refiners in the state, Atlantic Richfield, who has already developed a gasoline that can meet the new standards, vigorously backed the new standards.[7] Under the regulations passed, small refiners will be given until 1998 to comply. Nine eastern states and the District of Columbia by the end of the year were considering adoption of the California standards.[8]

In response to California regulations passed in 1990 stipulating that 2 percent of all vehicles sold by major auto makers produce zero emissions beginning in 1998 (10% by 2003), nearly all of the world's auto manufacturers have started electric car research programs. Impetus has been further provided by New York and Massachusetts who subsequently adopted nearly identical standards. Skeptics concerning the attractiveness of electric vehicles to customers abound; they point to the short range compared to gasoline-fueled automobiles, the long charging times, and uncertainties relating to the adequacy of the heating system in cold climates which will also have to be electrical. Nonetheless with the likelihood of future contraction of the State's aerospace and defense industries, many companies see opportunities in "high tech" transit.[9] A case in point is Calstart, a public-private consortium supported by the State of California and the federal government, which unveiled a state-of-the-art electric vehicle in 1992 containing components from at least seventeen California companies.

OIL AND GAS PRODUCTION

Oil Production

California oil production remained close to 1990 levels thus arresting a steady decline from the peak year of 1985.[10] While production from onshore fields and offshore wells in state waters continued to decline, the start-up of production from the Point Arguello field in federal waters northwest of Santa Barbara more than compensated. The Point Arguello field, the largest discovered in the US since the discovery of Alaska's Prudhoe Bay, had been idle for three years because of disputes between Chevron and its partners, who proposed to transport the oil by tanker to Los Angeles refineries, and the local Santa Barbara officials, who preferred that the oil be moved to shore by pipeline. Existing pipelines moved up to 46,000 barrels per day of the 75,000-100,000 barrel per day potential to shore in 1991. The oil was then piped north to Chevron's Martinez refinery where about half was refined; the remainder was shipped by tanker to Los Angeles thereby circumventing the Santa Barbara County restrictions.[11] At year's end the operators and Santa Barbara County officials remained at loggerheads as to how to transport the remaining idled production to Southern California refineries.

Enhanced oil recovery accounted for about 62% of California's total oil production, 80% of which was by steam stimulation and the remainder by water flooding. Increases in production in various fields where recorded were credited to new and enlarged steam projects, notably at the Midway-Sunset, Cymric and Lost Hills fields in the San Joaquin Valley. Production at the Midway-Sunset field reached the highest level since its discovery in 1894. It was the largest producer in the state as well as the largest producer in the lower 48 states. Its accumulative production of over 2 billion barrels has only been exceeded by three other US fields (Prudhoe Bay, AK, East Texas, TX and Wilmington, CA).

By the end of 1991 construction of the 904 mile Kern River and Mojave natural gas pipelines was near completion. The two lines will carry 700 and 400 million cubic feet of natural gas per day respectively to California for enhanced oil recovery projects. The natural gas will replace crude oil now burned by oil producers to raise steam. Many of the enhanced oil recovery projects are cogeneration operations in which surplus power is sold to either Pacific Gas and Electric Co. or Southern California Edison Co. The maximum power output is rated at 2126 MW from all oil field cogeneration projects in California.[10]

Natural Gas Production

Natural gas from associated with oil production provides a little more than half of California gas production. The remainder comes from "non-associated" gas fields such as located in the delta of the Sacramento River. The total supply from California sources rose slightly in 1991 for the first time since 1985. Nonetheless the long term prognosis is a slow decline in both associated and non-associated gas.

NATURAL GAS SUPPLY

Natural gas consumed in the State comes from California (18%), Canada (19%) and imports from other western states (63%) (Figure 1). The growing market for natural gas as a fuel in enhanced oil recovery and cogeneration and self-generation by industrial users has spawned a number of pipeline proposals (Table 6) to bring additional gas into the State.

Table 6. Status of California Pipeline Proposals 1991[12]

Project	Miles	Capacity (Bcf/d)
Completed or under construction	2507	2.743
Approved but not started	620	0.719
Proposed or pending	619	1.402
Total	3746	4.864

More than half of gas included in the proposed additional capacity of 4.864 Bcf is to come from Canada. The largest project has been undertaken by Pacific Gas Transmission Co. (PGT), a subsidiary of Pacific Gas and Electric Co. Construction of the pipeline, which goes from Alberta to Central California, got underway at the end of the year. The 42 inch pipeline runs parallel to an existing PGT pipeline and will expand transmission from 1.5 to 2.4 billion cubic feet per day.[13] Construction is not anticipated to be affected by Pacific Gas and Electric Co.'s sale of its subsidiary to TransCanada PipeLines Ltd. In rate hearings in front of the California Public Utilities Commission (CPUC), Pacific Gas and Electric Co. has long been accused of indifference to the price of Canadian gas partially because its pipeline revenues are based on volume rather than the price of the gas. By selling its out-of-state pipelines it will have an easier time showing that there is no conflict of interest in securing Canadian gas for import.

In a significant ruling, the CPUC adopted a policy designed to open up California pipelines to non-core customers and to allow them to arrange gas purchases themselves.

Demand for natural gas is expected to increase by 2.1 Bcfd by 2010 by CPUC and the California Energy Commission[12], thus it seems certain that not all of the projects included in Table 6 will come to fruition. Most vulnerable is a 719 Bcf/d line (Altamont) proposed between Alberta and California which, if completed in the same time frame as the PGT pipeline, might result in a surplus of gas. In fact, in August 1992 sponsors announced that its construction would be delayed one year because of uncertain economic conditions in the State.[14]

ELECTRICAL POWER

Source of Supply

Table 7 summaries the principal sources of California's electricity. Most were affected by decreased demand in 1991 reflecting the recession that existed throughout the year. Hydropower was especially impacted by the five year drought the state has experienced. Historically the State has relied on in-state hydropower to supply a quarter of the electricity transmitted by the utilities to customers (Figure 4); however in recent years the percent has been half that. Imports principally from the Pacific Northwest remained the State's largest single source of electricity. Utility generating capacity at approximately 44 GWe (Table 8) is augmented by 7-8 GWe from municipal

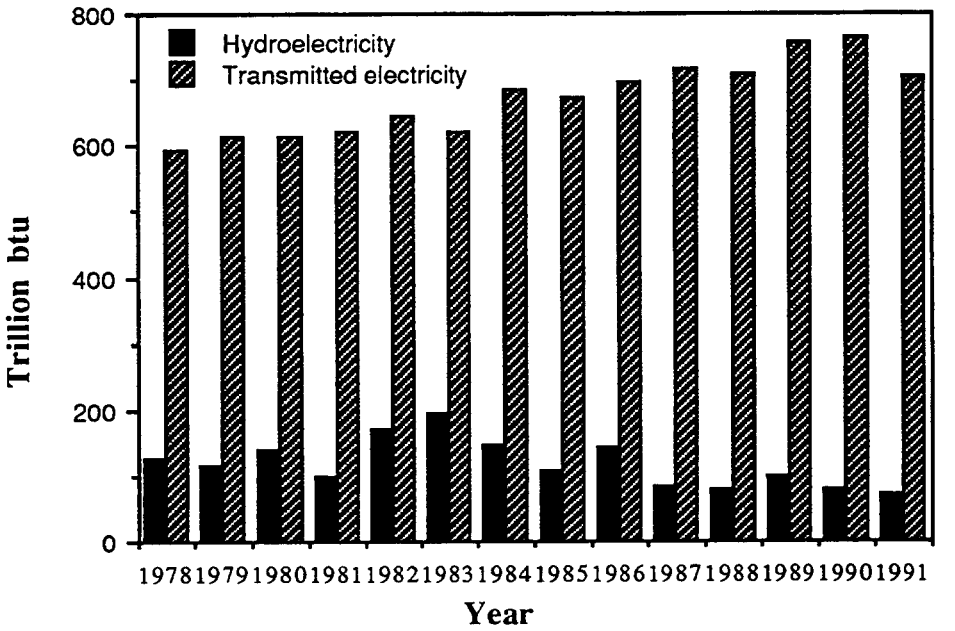

Figure 4. Effects of the 1987-1991 drought on in-state hydroelectricity transmitted by California utilities

Source: Electric Power Annuals- 1978-1990, DOE/EIA-0348; Electric Power Monthly, DOE/EIA-0226(92/03), Department of Energy, Washington DC.

Table 8. California Utility Electrical Generating Capacity[15]

Primary energy source	Capacity (GWe)
Petroleum	2.87
Gas	21.26
Water	12.76
Nuclear	4.75
Other (principally geothermal)	1.96
TOTAL	43.60

*Summer capability as of December 31, 1991

The proposed merger of Southern California Edison Co.(SCE) and San Diego Gas and Electric Co. (SDG&E) received a final denial from the CPUC.[16] SDG&E is a small utility that has lacked generating power. Costs associated with the ill-fated Sundesert nuclear plant prior to its abandonment more than a decade ago were financially deleterious. In the interim SDG&E has not been able to develop additional generating capacity. Through the merger it had hoped to take advantage of SCE's surpluses. The merger was denied on the grounds that it would hurt competition among remaining utilities in the West since the merged companies would become the single largest investor owned utility in the country. Currently Pacific Gas and Electric Co. in Northern California holds that title.

The availability of surplus generating capacity in the State together with a drop in demand because of the economic recession have been fortunate for the Sacramento Municipal Utility District (SMUD). Its poorly performing Rancho Seco nuclear plant, which represented one half the district's generating capacity, was closed in 1989 by voter referendum. The utility submitted its plan for decommissioning the 913 MW plant to the Nuclear Regulatory Agency in 1991.[17] In the short term, SMUD plans to build gas-fired cogeneration plants and buy power from neighboring utilities; in the long term it hopes that its newly inaugurated programs to promote conservation and national efforts to develop economical renewable forms of energy will come to fruition.

Renewable and alternate sources of electricity

Geothermal power

After hydroelectric power the largest source of renewable or alternate energy utilized in the State is geothermal power. The principal geothermal field is The Geysers in Northern California, the largest in the world. The first commercial well began to operate in 1960, and currently there are 437 steam producing wells and 26 injection wells spread over a 16 square mile area within Lake, Napa, Sonoma and Mendocino counties. In the mid-80's steam pressure in the field began to drop, and despite a stepped-up reinjection program by the several operators, decline has continued through 1991 (Figure 5). Electric generating capacity utilized in 1991 was about 1500 MW, reflecting closure of three generating units and inadequacy of the steam supply to keep all generating units operating. The prognosis is for a continuing decline in output into the foreseeable future at that site.

Fortunately new geothermal generating facilities (Table 9) are coming on line at other locations in the State. Most noteworthy to date are the Coso Geothermal Resource area within the China Lake Naval Weapons Center, Inyo County, the Salton Sea Geothermal Field, and the East Mesa Geothermal Field in Southern California, all of which are so-called water-dominated geothermal fields requiring larger withdrawals than steam-dominated fields such as The Geysers (see Table 9).

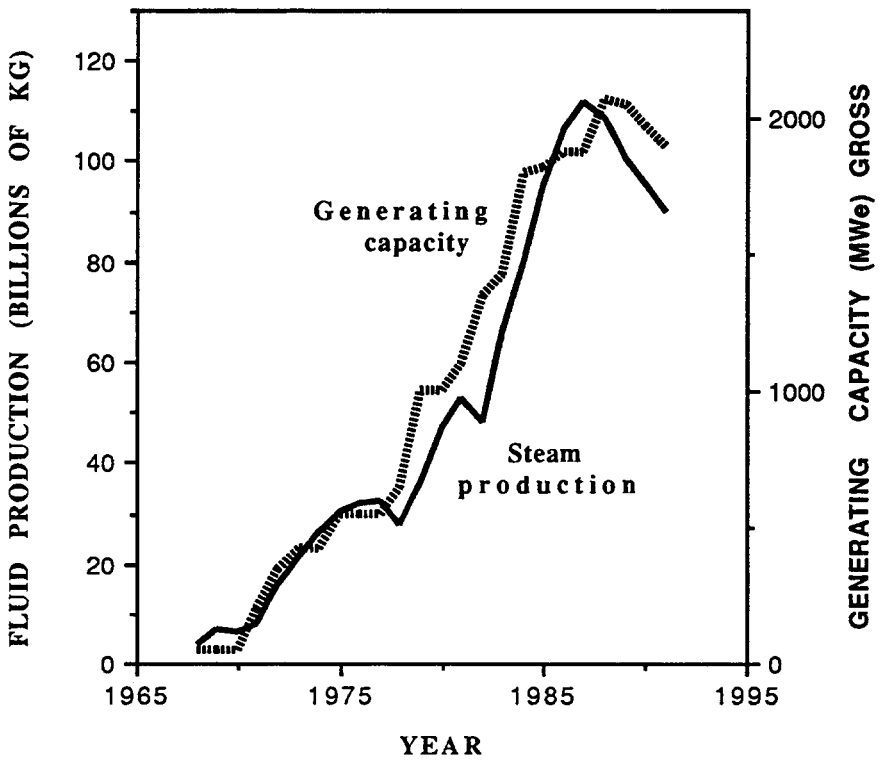

Figure 5. Production and gross generating capacity at The Geysers geothermal field[10]

Table 9. Principal Geothermal installations in California (1991)[10]

Field	Gross installed capacity (MWe)		Steam/fluid production (billions of kilograms)	
	1990	1991	1990	1991
Coso Hot Springs	260	260	55.9	46.6
East Mesa	130	130	79.2	91.9
The Geysers	1975	1900	95.6	89.7
Heber	50	50	29.5	29
Mono-Long Valley	40	40	7.0	24.5
Salton Sea	240	240	75.5	77.7
Wendell-Amedee	3	3	8.0	8.2
Total	2698	2623	350.7	367.6

Nonetheless these new additions to the geothermal contribution to total electrical supply have not compensated for the decline in output at The Geysers (Compare Figure 1 and 2).

Solar electricity

Solar energy in the US is utilized chiefly in production of hot water. Its contribution to energy supply is not accurately known since installations tend to be located at small residences and commercial establishments where use goes unrecorded. Similarly, the extent of the use of photo voltaic electrical generators in typically small and isolated area is not accurately known. The only large (>100 MW) solar electrical generating facilities in the State are experimental in nature. Noteworthy is the 150 MW plant in the Mojave Desert built by Luz International Ltd. In 1991 the company was granted a $6.4 million property tax cut on its properties in order to continue to expand its operation.[18]

Three utilities (Los Angeles Department of Water and Power, Sacramento Municipal Utility District and Southern California Edison Co.) continued to develop plans for a 10 MW experimental plant, Solar Two, in the Mojave desert. Its unique feature is the use of molten salts (nitrates) pumped to the top of a 300-foot tower to store the heat collected by hundreds of large mirrors. The Department of Energy is expected to fund half of the costs of the plant which should be completed by 1994.[19]

Windpower

Wind power continued to grow in California despite the lapse of tax credits and substantial rate incentives that were associated with its early development years. The State's wind farms are the largest in the world and currently provide about 1.5% of transmitted electricity (Figure 1). Capacity factors remain below optimum (Table 10); however they too are increasing as the technology matures. The large number of marginally efficient and unreliable wind turbines erected in the 80's have largely disappeared. In jest they were said to have generated more tax credits than electricity. The new generation of wind turbines produces electricity at about 5 cents a kilowatt-hour including capital investment, operation and maintenance according to US Windpower.[20] Estimates from other sources range from 5-8 cents per kilowatt-hour[21], which make it nearly competitive with conventional oil and gas for generating electricity.

Eight US wind companies received federal funding for renewable energy research and development. The $5 million cost-shared program will focus on new power processing systems for smaller turbines, the development of an improved hybrid wind-diesel power system and the development of new blades using advanced airfoils.[21]

Table 10. Windpower Installations in California as of January 1

Location	Capacity (MWe)				Number of turbines			
	1989	1990	1991	1992	1989	1990	1991	1992
Altamont Pass area, 45 miles east of San Francisco	623	659	687	704	6062	6242	6524	6818
San Gorgonio Pass, Riverside Co. near Palm Springs	206	224	229	255	3322	3388	3333	3581
Tehachapi Pass, Kern Co.	370	417	477	644	4007	4414	4422	5221
Mojave Desert, Kern Co.				nd				nd
Boulevard, San Diego Co.				nd				nd
Carquinez Strait, Solano Co.	2	2	61	60	66	62	631	600
Pacheco Pass, San Benito Co.				16				167
Salinas Valley				nd				nd
TOTAL	1202	1302	1454	1679	13457	14106	14910	16387
Capacity Factor	17	18	20	20				

nd signifies that no data was reported to CA Energy Commission.

Source: Results from the Wind Project Performance System, Annual Reports, 1988, 1989, 1990, 1991 California Energy Commission, Sacramento, CA.

APPENDIX A

Energy balance for 1991 (Figure 1)

SUPPLY			(10^{12} Btu)
Electrical Imports			375
Wind			10
Hydro			80
Cogenerated electricity (fuels included in oil and gas supplies below)			
Geothermal			144
Nuclear			338
Miscellaneous electricity			10
Natural gas			2089
Less: unaccounted for gas and net storage additions			-21
Coal			63
Petroleum			4183
Less exports			-447
Total			6824
DISPOSITION			
Useful energy			2921
Residential/commercial		1009	
Industrial		1212	
Transportation		700	
Non-energy uses			245
Rejected energy			3749
Residential/commercial		433	
Industrial		404	
Transportation		2100	
CA electric utility generation		682	
Fossil fuels	326		
Nuclear	230		
Hydro	8		
Geothermal	118		
Out-of-state elec. generation and transmission losses		130	
Cogeneration (included in industrial)			-91
Total			6824

APPENDIX B

Data Sources for California Energy Supply (1991)

Production	Source
Crude Oil including Federal Offshore and Lease Condensate	Ref. 10.
Associated and Nonassociated Natural Gas (marketed, dry)	Ref. 22, Table 48, Summary Statistics for Natural Gas - California.
Electric Utility Fuel Data	Ref. 23, Table 22, Consumption of Petroleum to Produce Electricity; Ref. 22, Table 48.
Electrical Generation Oil, gas, hydro, nuclear,	Ref. 23, Tables 8,11,14,15 and 16 Net Generation by Petrol., Gas, Hydroelectric, Nuclear Power and Other.
Wind	Ref. 24.
Cogeneration	Andrea Gough, California Energy Commission, personal communication, Dec 1, 1992.
Imports	
Natural Gas	
Foreign	Ref. 22, Table 9.
Domestic	Ref. 22, Table 48.
Crude Oil Foreign and Domestic	Ref. 25, Table 1-A, California Petroleum Summary.
Oil Products Foreign and Domestic	Ref. 25, Table A-1, California Petroleum Fuels Market Activity.
Coal	Ref. 26, Table 24, Coal Consumption by Census Division and State.
Electrical Power Net Exchange	Andrea Gough, California Energy Commission, personal communication, Dec. 1, 1992.
Coal	Ibid.
Exports	
Oil Products Foreign and Domestic (not including bunkering fuel supplied at California ports)	Ref. 25, Table A-1.

APPENDIX C

Data Sources for California End Uses (1991)

Net Storage	
Natural Gas	Ref. 22, Table 48.
Unaccounted for Natural Gas	Ref. 22, Table 48.
Transportation	
Crude Oil	
Gasoline, Aviation and Jet fuels	Ref. 25, Table 1-A.
Taxable Diesel Fuel (for public highways)	Ref. 27, Table 4, Sales for Transportation Use: Distillate Fuel Oil End Use, 1991.
Vessel Bunkering (includes international bunkering)	Ref. 27, Table 4 & 5.
Rail Diesel	Ref. 27. Table 4.
Military Use	Ibid.
Natural Gas	
Pipeline fuel	Ref. 22, Table 48.
Industrial, Government, Agriculture, etc.	
Natural Gas (includes lease and plant fuel)	Ref. 22, Table 48.
Coal	Ref. 26, Table 24.
Electricity	Ref. 23, Table 54, Sales of Electricity to Ultimate Consumers by Class of Service, Year to date.
Crude Oil	By Difference.
Non Energy Applications	
Crude Oil and LPG	
Asphalt	Ref. 28. (estimate)
Petrochemical Feedstock	Ref. 29, Table 45 (estimate).
Waxes, Lubricating oils, Medicinal uses, Cleaning	Ref. 25, Table A-5, California Refinery Activity by Type and Area.

Residential and Small Commercial	
Natural Gas	Ref. 22, Table 48.
Crude Oil and Other Oils (kerosene, residual, and distillate)	Ref. 27, Table 6, Sales of Kerosene by End Use; Table 5, Sales of Residual Fuel Oil by End Use; Table 4, Sales of Distillate Fuel Oil by End Use.
LPG	Ref. 29, Tables 43 & 44.
Miscellaneous "Off highway" Diesel	Ref. 27, Table 4.
Electricity	Ref. 23, Table 54.

APPENDIX D

Conversion Units

Energy Source	Conversion factor, 10^6 Btu
Electricity	3.415 per million Wh
Coal	22.6 per short ton
Natural Gas	1.05 per Mcf
Crude Oil	5.80 per barrel
Fuel Oil	
Residual	6.287 per barrel
Distillate, including diesel	5.825 per barrel
Gasoline and Aviation Fuel	5.248 per barrel
Kerosene	5.67 per barrel
Asphalt	6.636 per barrel
Road Oil	6.636 per barrel
Synthetic Rubber and Miscellaneous	
LPG Products	4.01 per barrel

Assumed Conversion Efficiencies of Primary Energy Supply

Electric Power Generation	
Hydro Power	90%
Coal	30%
Geothermal	18%
Oil and Gas	33%
Uranium	32%
Transportation Use	25%
Residential/Commercial Use	70%
Industrial Use	75%

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